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Use of Small-Diameter Bladder Pumps in Direct-Push Ground Water Monitoring Wells at the CRREL Site

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ABSTRACT

Several different small-diameter (1/2-inch and 3/4-inch) bladder pumps (from different manufacturers) were tested in 1/2-inch and 3/4-inch direct-push (DP) monitoring wells at the CRREL site in Hanover, New Hampshire. Obtaining a sample at this site has been challenging because the depth to ground water is over 100 feet and thus substantial lift is required to bring the water to the surface. Although the different brands of pumps fit into the small-diameter wells, all of them hung up in some of the wells when attempting to install them at the sampling depth. However, it was found that machining a few thousandths of an inch off the diameter of the pumps was all that was necessary to get them to the desired depth. Three brands of 3/4-inch bladder pumps were tested in the site's DP wells and delivered between 25 and 315 mL/min. Two brands of 1/2-inch bladder pumps were tested and delivered between 20 and 100 mL/min. Concentrations of TCE obtained using two different brands of a 3/4-inch diameter pump were compared and statistically significant differences were found. The same was true when the same two brands of 1/2-inch diameter pumps were compared, although the differences in this case were slight. It is believed that differences in the previous conditioning the pumps received in the wells (i.e., equilibration times for the materials with the well water) were responsible for much of these differences.

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CONVERSION FACTORS, NON-SI TO SI UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To obtain
feet	0.3048	meters
inches	0.0254	meters

PREFACE

This report was prepared by Louise V. Parker, Research Physical Scientist, Applied and Military Engineering Branch, Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory (ERDC-CRREL), Hanover, New Hampshire; John W. Govoni, Research Technician, Snow and Ice Research Branch, ERCDC-CRREL; and Martin H. Stutz, Senior Chemist, Technology Branch, Acquisition and Technology Division, U.S. Army Environmental Center (USAEC), Aberdeen Proving Ground, Maryland. This report was prepared under the general supervision of Dr. Justin B. Berman, Chief, Applied and Military Engineering Branch, CRREL; Dr. Lance D. Hansen, Deputy Director, CRREL; and James L. Wuebben, Acting Director, CRREL.

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Use of Small-Diameter Bladder Pumps in Direct-Push Ground Water Monitoring Wells at the CRREL Site

LOUISE V. PARKER, JOHN W. GOVONI, AND MARTIN H. STUTZ

1 BACKGROUND

The CRREL site was one of five sites selected for a recent Department of Defense Environmental Security Technology Certification Program (ESTCP)-sponsored demonstration on the long-term use of direct-push (DP) monitoring wells. The reason the CRREL site was selected for the ESTCP demonstration was to test DP well technology under the more rigorous conditions found at this site with respect to soil type and depth to ground water. The CRREL site is situated on glacial deposits that consist of silt/very fine sand and silt/sand mixtures. Three existing conventionally installed hollow-stem auger (HSA) monitoring wells were selected for the ESTCP demonstration. The depth of these wells ranged from 116.5 to 136.5 feet, and the depth to ground water ranged from 95 to 125 feet. In September 2000, ½-inch-diameter pre-pack Geoprobe wells were installed in close proximity to each of the three conventional monitoring wells. In August 2002, ¾-inch diameter pre-pack Geoprobe wells were installed at the same three locations, making three well clusters consisting of three well types: a conventional HSA well, a ½-inch DP well, and a ¾-inch DP well. In all cases, installation of the DP wells went very quickly. As an example, Geoprobe pushed the 2.125-inch-diameter drive rod (for a ¾-inch DP well) to a depth of 138 feet in 60 minutes. The DP wells were developed by manually surging and purging the well using a Geoprobe inertial check valve assembly attached to the bottom of (0.375-inch-OD, 0.25-inch-ID) polyethylene tubing.

While we found installation of the DP wells went very quickly, we encountered a number of problems when we tried to sample these wells. At the time the three ½-inch-diameter DP wells were installed, only one bladder pump was commercially available that would fit such small-diameter wells. This pump was developed and manufactured by Precision Environmental Equipment, Inc. (Villa Park, Illinois) and is available through Geoprobe Systems, Inc. (Salina, Kansas). The first problem we encountered was that while all three ½-inch-diameter

pumps fit into the DP wells, two of them hung up in the wells and could not be lowered to their target depths. We tried lightly reaming out the wells, but when that did not work, we were hesitant to continue with this reaming effort because we feared doing so might perforate the casing wall. We found that by using slightly thinner-walled tubing and machining off a few thousandths of an inch from the diameter of the pump, we were able to install all three pumps at the desired depths.

Once we installed the pumps in the ½-inch DP wells, we found that the pump could not overcome the lift required to bring the water to the surface. The manufacturer then tried several other pump designs to solve this problem but ended up redesigning the controller for higher pressures and using a more flexible material in the bladder.

With the newly redesigned system, we were able to obtain 20 to 60 mL/min with these pumps in the ½-inch DP wells but found that after approximately 30 minutes, the flow rate declined to a few mL/min. When the pumps were removed from the wells, the manufacturer determined that the diminished capacity was due to water that condensed in the compressed air line. To remedy this situation, the manufacturer added a water trap containing drying agent to the line going from the compressor to the controller.

2 OBJECTIVES

Because of the problems we had encountered trying to sample the ½-inch diameter wells, this project was designed to determine the state of the art for small-diameter pumps. Our primary focus was on bladder pumps that could be used in conjunction with low-flow sampling protocols. Specifically, we surveyed the pump manufacturers to determine what ½-inch and ¾-inch bladder pumps were either commercially available or in development (i.e., there was a prototype that could be tested). Having found several different pumps to test, our objectives were to test their performance in our DP wells and to compare different brands of (the same diameter) pumps to determine whether they delivered an equivalent concentration of TCE from one of our monitoring wells.

3 MATERIALS AND METHODS

Monitoring wells

The conventional monitoring wells used in this study were constructed of four-inch-diameter PVC casing, each with a 10-foot-length slotted, PVC screen. Construction of the ¾-inch- and ½-inch-diameter Geoprobe wells was closely matched with the conventional wells with respect to screened interval (Table 1) and materials. The ¾-inch wells were constructed of PVC casing with a 10-foot screen contained within a Geoprobe pre-pack filter with a stainless steel screen. The ½-inch diameter Geoprobe wells were constructed of PVC casing with a 9-foot screen contained within a Geoprobe pre-pack filter with a stainless steel screen.

Table 1. Depth of screened interval and static water level in wells.

		Depth of screened interval (ft)		
Cluster	**Depth to water table (ft)**	**Conventional monitoring well**	**1/2-inch DP well***	**3/4-inch DP well**
9	125.4	126.5–136.5	129–138	127–137
10	111.5	117–127	117.5–126.5	117–127
11	95.2	106.5–116.5	105.5–114.5	106.5–116.5

* 9-ft screen

Commercially available and prototype bladder pumps

During the course of this investigation the performance of seven different bladder pumps, in varying stages of development, was evaluated. Several pneumatically driven bladder pumps were commercially available. These included the ½-inch-diameter pump previously mentioned and three ¾-inch-diameter pumps: one developed and manufactured by Precision Environmental Equipment, Inc. and distributed by Geoprobe Systems, Inc. (Salina, Kansas; www.Geoprobe.com); another developed and sold by QED Environmental Systems, Inc. (Ann Arbor, Michigan; www.qedenv.com); and one developed by Innovative Sampling Systems, Inc. and distributed by Durham-Geo Slope Indicator (Stone Mountain, Georgia; www.durhamgeo.com).

Three prototype bladder pumps also were tested. These included a ½-inch pneumatic pump being developed by Innovative Sampling Systems, Inc.; a mechanically driven ½-inch pump in early stages of development by Geoprobe

Systems, Inc., and a 3/8-in. pump being advertised (but which was not yet available) by Solinst Canada Ltd. (Georgetown, Ontario, Canada; www.solinst.com). The later pump was designed specifically for use in the individual channels of the multichannel tubing used in the Solinst CMT Multilevel System.

To simplify discussion from now on, the pumps developed by Innovative Sampling Systems, Inc., will be referred to as ISS pumps and the pumps developed by Precision Environmental Equipment, Inc., will be referred to as the PE pumps. Table 2 summarizes the characteristics of the pumps in this study.

Operability studies

Whenever possible, each pump was tested in its respectively sized DP well to determine 1) whether we were able to get the pump to the desired depth in these wells, 2) whether the pump was able to function under the static lift conditions required in these wells, and 3) the maximum obtainable flow rate.

Sampling studies

In these studies, the pumps were tested to determine whether they delivered equivalent concentrations of TCE from one of our deep monitoring wells. The pumps were tested in one of the larger conventional monitoring wells rather than a DP well to circumvent the issues associated with using a small-diameter DP well that could accommodate only one pump at a time. These issues included elevating the turbidity each time a different pump is placed in the well and allowing adequate time for the well to re-equilibrate, which could result in having to sample on different days.

At the time we were ready to conduct this study there were only two ½-inch pumps and two ¾-inch pumps (the PE and ISS pumps) available for comparison. The two ¾-inch pumps were tie-wrapped together and placed so that the inlet of each pump was at 111.5 feet. Samples were taken using first one pump and then the other pump until four pairs of samples had been obtained. For the first two sampling rounds, the ISS pump was used first and then the PE pump was used. For the third and fourth sampling rounds, the sampling order was reversed. The well was sampled using an EPA low-flow sampling protocol (US EPA Region 1 1996), at a flow rate of approximately 75 mL/min. Concentrations in this well were approximately 5 mg/L. A similar sampling protocol was used to compare the ½-inch pumps, except that the flow rate was approximately 35 mL/min. No measurable drawdown of the water level has been observed in this well at these pumping rates.

Table 2. Pump properties.

Type	Diameter (in.)	Developer	Commercial source	Product name	Length (in.)	Pump materials	Tubing materials
Pneumatic	3/4	Precision Environmental, Inc.	Geoprobe Systems Salina, Kansas www.Geoprobe.com	Pneumatic Bladder Pump	20	SS body, PTFE bladder	FEP inner, HDPE outer
Pneumatic	3/4	Innovative Sampling Systems, Inc.	Durham Geo Slope Indicator Stone Mountain, Georgia www.durhamgeo.com	Mini Bladder Pump	18	SS body, flexible Teflon bladder	PTFE-lined polyethylene
Pneumatic	3/4	QED Environmental Systems, Inc.	QED Environmental Systems, Inc. Ann Arbor, MI www.qedenv.com	Sample Pro Portable Pump	10.5	SS body, PE bladder	Tubing to fit fittings for ¼-inch (OD) air line and 1/8-inch (OD) sample line
Pneumatic	1/2	Precision Environmental, Inc.	Geoprobe Systems Salina, Kansas www.Geoprobe.com	Pneumatic Bladder Pump	18	SS body, PTFE bladder*	FEP inner, LDPE or FEP outer
Pneumatic	1/2	Innovative Sampling Systems, Inc.	Durham Geo Slope Indicator Stone Mountain, Georgia www.durhamgeo.com	Mini Bladder Pump	18	SS body, flexible Teflon bladder	PTFE-lined polyethylene
Mechanical	1/2	Geoprobe Systems	Geoprobe Systems Salina, Kansas www.Geoprobe.com	Mechanical Bladder Pump	26.5 inch for SS screen inlet filter 20.5 inch for bullet nose inlet	SS body, FEP bladder	FEP or LDPE inner, HDPE outer
Pneumatic	3/8	Solinst Canada	Not commercially available	N/A			

FEP = Fluorinated ethylene-propylene
HDPE = High-density PE
LDPE = Low-density PE
PE = Polyethylene
PTFE = Polytetrafluoroethylene
SS = Stainless steel
* A more flexible material was used in this study.

Chemical analyses

Samples were collected in glass 40-mL VOA vials, being careful to eliminate any bubbles or headspace, and sealed with Teflon-lined caps. These vials were stored in a refrigerator until the samples were analyzed the next day. At that time, an aliquot was transferred to a glass, 1.8-mL autosampler vial using a glass Pasteur pipet.

Analytical determinations were performed using reversed-phase HPLC (RP-HPLC) as described by Parker and Clark (2002). The UV detector was set at 215 nm, and separations were obtained on a 25-cm × 0.46-cm (5-µm) LC-18 column (Supelco) and eluted with 65/35 (V/V) methanol/water at 1.5 mL/min. The detector response was obtained from the digital integrator operating in the peak height mode.

A 2,240 mg/L primary standard was made by adding a known amount of neat TCE to methanol in a 50-mL glass volumetric flask and then weighing the flask. This standard was kept in the freezer. On analysis days, working standards were made by dilution of the primary standard into deionized water. These standards ranged in concentration from 2.24 to 11.2 mg/L.

Statistical analyses

The data sets were found to be normally distributed (using a P value of 0.050), and thus did not require any transformation or the use of non-parametric statistical analyses. A Paired t-test (at 95% confidence level, $\alpha = 0.05$) was used to determine whether there was a significant difference between TCE concentrations from the two different ¾-inch pumps. A similar paired t-test was used to compare the data from the ½-inch pumps.

4 FINDINGS

Operability studies

The findings from these studies are summarized in Table 3.

½-inch Precision Environmental Equipment (Geoprobe) pneumatic bladder pump

Most of our work with this pump took place prior to this study and was discussed in the Background section of this report. When we began this project, the manufacturer had added a water trap to the air line to prevent or reduce issues with condensation in the air line. However, we found that drying agent in the trap quickly took on water and had to be replaced or regenerated daily. Initially, we tried to regenerate the drying agent by drying it in a laboratory oven. However, we found that, with repeated use, the drying agent began to disintegrate into fine particles, which got into the controller and caused it to fail. To solve this, we added a particle trap to the system and replaced the drying agent after every use.

We also observed that our air compressor ran almost constantly and felt this might account for some of the issues we had with water condensing in the air lines. We tested a larger capacity air compressor but found that it did not work as well as the smaller air compressor did. We believe this was because the larger air compressor actually let the pressure drop to lower pressures than the smaller compressor did.

At the developer's suggestion, we used a higher air pressure hose with this system and found this greatly improved the performance of this pump. We were able to get average flow rates of 40 mL/min from DP9 and 50 mL/min from MW10. However, since then, we have not been able to consistently sample from DP9 (the well requiring the greatest lift) during our regular sampling events (for the ESTCP DP-well demonstration). It appears that we have reached the capacity of this pump with respect to the lift required. We also have found that the controller functions better in a heated tent when temperatures fall below 40ºF.

¾-inch Precision Environmental Equipment pneumatic bladder pump

We were able to get this pump to the desired depth in all three wells. However, when we initially tested this pump in one of our DP wells (#11), we were able to obtain only 19 mL/min. We determined that there was a problem with the controller that was due to clogging from the fine particles from the disintegrating drying agent that eventually caused the controller to fail. Once this problem was corrected, the maximum flow rate we obtained with this pump was 80 mL/min, which was in our deepest well that required the most lift.

Table 3. Summary of findings from operability study.

Pump diameter (in.)	Developer	Pump type	Test DP well	Lift required	Pump to depth?	Delivers water?	Maximum flow rate
3/4	PE	Pneumatic	9	125 feet	+	+	80 mL/min
			10	111 feet	+	+	68 mL/min
			11	95 feet	+	+	72 mL/min
3/4	QED	Pneumatic	9	125 feet	+	+	25 mL/min
			10	111 feet	–	N/A	
			11	95 feet	+	+	60 mL/min
3/4	ISS	Pneumatic	9	125 feet	+	+	315 mL/min
			10	111 feet	–	+	274 mL/min
			11	95 feet	+	+	99 mL/min
1/2	PE	Pneumatic	9	125 feet	–	–	9 mL/min[2]
			10	111 feet	–	+	21 mL/min[2]
			11	95 feet	+	+	50 mL/min[2]
1/2	ISS	Pneumatic	9	125 feet	N/A[1]		
			10	111 feet	N/A[1]		
			11	95 feet	–	+	99 mL/min
1/2	Geoprobe	Mechanical	9	125 feet	N/A		
			10	111 feet	N/A		
			11	95 feet	+	+	152 mL/min[3]
3/8	Solinst	Pneumatic	9	125 feet	N/A		
			10	111 feet	N/A		
			11	95 feet	+	+/–	Trickle

[1] We were unable to test this pump in this well because we did not have long-enough tubing for the well.

[2] Maximum flow rates we currently get with system.

[3] The pump was operated by hand, and this rate was determined during a minute trial. However, we would not have been able to operate this pump by hand at this rate for a long enough time to obtain a sample using a low-flow sampling protocol.

¾-inch QED pneumatic bladder pump

This pump is designed for direct-push applications and has a disposable bladder. Although this pump fit in all three DP wells, we were able to get it to depth in only two of the wells. Because this pump was being demonstrated to us by the manufacturer for only a brief time, we did not try to reduce the diameter of the pump. However, based upon our findings with the other pumps, we are fairly confident that if we had done this, the pump would have fit in the third well. We were able to recover 25 to 60 mL/min in the two wells that the pump fit into.

¾-inch Innovative Sampling Systems or Durham-Geo mini bladder pump

Again, we were not able to get one of the pumps to the desired depth in one of the ¾-inch DP wells and had to machine a few thousandths of an inch off the diameter of the pump to get it to the desired depth. Once installed, the pump delivered between 99 and 315 mL/min. On one sampling event in July (in very hot and humid weather), we noticed that after about an hour of pumping, the capacity of the pump dropped from 88 mL/min to 53 mL/min. We determined that this was due to water condensing in the air line. However, we have not found this to be an issue with this pump in any subsequent sampling events.

½-inch Innovative Sampling Systems or Durham-Geo mini bladder pump

Because this pump is a prototype pump and because we wanted to compare its performance with other pumps in DP 11, it was tested only in that well. Again, we had trouble getting the pump to depth in the well, so rather than machining a pump that was a prototype, we tested it in the ¾-inch DP well, where we were able to obtain a flow rate of 99 mL/min.

½-inch Geoprobe mechanical prototype bladder pump

We first tested this pump by operating it by hand in the lab and found that it worked well and was able to deliver 35 mL with 20 strokes. However, when we placed the pump in one of our DP wells and operated it by hand, the pump did not deliver water to the surface. We removed the pump from the well and tested it on the surface (with ~140 feet of tubing) in a bucket of DI water. We observed that the pump stroke was much shorter than when we had tested it in the lab (using a much shorter piece of tubing), i.e., there was almost no movement with the longer piece of tubing. We felt that there were several possible reasons why the pump did not work: 1) there appeared to be too much play in the inner tubing within the outer tubing, 2) there may have been too much friction between the

two lines of tubing to get a useful stroke for the bladder, and 3) we also observed that the inner tubing stretched with use.

Since then, Geoprobe has made several changes to address this issue and we have retested this pump. In one of our DP wells (# 11), we were able to get 25 mL with eight strokes or 106 to 152 mL in one minute. However, operating this pump by hand at this depth was very tiring, and it is doubtful that this pump could be operated by hand long enough to sample this well using a low-flow purge and sampling protocol. This pump and a 12-volt pump actuator (to operate this pump) are now commercially available. According to the manufacturer, this system works in wells with water tables at 50 to 75 feet and the manufacturer is trying to extend this capability.

Solinst 3/8-inch-diameter prototype micro bladder pump

We tested this pump at several pressures using several different on-off cycles and eventually were able to get the pump to deliver a few mL of water to the surface. However, we were not able to get the pump to produce more than a trickle. The developer is working to address these issues.

Sampling studies

Although we had not anticipated that there would be any difference in the concentrations of TCE in samples taken with the two different brands of ¾-inch bladder pumps, there was a statistically significant difference. Concentrations of TCE were significantly higher in the samples taken with the ISS pump than with the PE pump; mean concentrations were 5.1 vs. 3.7 mg/L, respectively (Table 4). We suspect that the reason for this difference was because the ISS pump had been left in the well for several months, and thus there had been time for the analytes in the well water (i.e., TCE) to equilibrate with the pump's materials, thereby reducing sorptive losses. In contrast, the PE pump had not been placed in the well until the day before the sampling event. Previous studies by our laboratory (Parker et al. 1990; Parker and Ranney 1994, 1997, 1998) have shown that TCE is readily sorbed by the polymeric materials used in bladder pump systems (e.g., fluorinated ethylene propylene [FEP]), and that losses are greater at lower flow rates and with longer lengths of tubing. This assumption (that differences in concentrations may be the result of differences in sorption that resulted from differences in the materials used and equilibration times) is borne out by the fact that the differences between the concentrations were less with each sampling event.

Table 4. Concentrations of TCE in samples taken using 3/4-inch diameter pumps.				
	Concentration (mg/L)			
Sample pair	**ISS pump**	**PE pump**	**Difference**	**RPD***
1	4.90	3.39	1.51	36
2	5.19	3.61	1.58	36
3	5.11	3.82	1.29	29
4	5.02	3.83	1.19	27
Mean	**5.06**	**3.66**	**1.40**	**32**
* RPD = Relative Percent Difference = (Difference/ Mean) × 100				

When we compared the two ½-inch pumps, again there was a statistically significant difference between samples taken with the ISS pump vs. those taken with the PE pump. Although the differences were much smaller this time, mean concentrations were 5.6 vs. 5.3 mg/L, respectively (Table 5). We suspect the reason this difference was considerably less for these pumps than what we observed for the ¾-inch pumps was because, in this case, the PE pump had been left in the well for several months, thereby allowing the bladder and some of the tubing materials to equilibrate with the well water.

While it appears that the PE pump system has more sorptive materials than the ISS pump system, these differences do not appear to be large when the pump is left in the well for a long enough time to equilibrate.

Table 5. Concentrations of TCE in samples taken using 1/2-inch diameter pumps.				
	Concentration (mg/L)			
Sample pair	**ISS pump**	**PE pump**	**Difference**	**RPD***
1	5.34	5.29	0.05	0.9
2	5.66	5.32	0.34	6.2
3	5.70	5.39	0.31	5.6
4	5.57	5.36	0.21	3.8
Mean	**5.57**	**5.34**	**0.23**	**4.2**
* RPD = Relative Percent Difference = (Difference/ Mean) × 100				

5 CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to determine whether there were pumps that would function well in our small-diameter wells, especially given our lift requirements. We found that there are several ½-inch- and ¾-inch-diameter bladder pumps that are commercially available that perform well even when a lift of more than 100 feet is required. Development also continues on other small-diameter bladder pumps, including one to fit in the 3/8-inch-diameter tubing of the Multichannel System. Because some equipment tested in this study is routinely used at our sites while other equipment was loaned or demonstrated for a limited time, we had more time to work with some of the pumps than with others. For this reason, our findings should not be used as absolute measure of the pumps' performance.

The progress made in this study would not have been possible without the cooperation and effort of the developers of these pumps and we are greatly appreciative of this. However, we would recommend that they pay attention to the issue of clearance in these small-diameter wells and perhaps produce a product that is a few hundredths of an inch less in diameter.

REFERENCES

Parker, L.V., A.D. Hewitt, and T.F. Jenkins (1990) Influence of casing materials on trace-level chemicals in well water. *Ground Water Monitoring Review* 10, no. 2: 146–56.

Parker, L.V., and T.A. Ranney (1994) Effect of concentration of dissolved organics on sorption by PVC, PTFE, and stainless steel casings. *Ground Water Monitoring and Remediation* 14, no. 3: 139–149.

Parker, L.V., and T.A. Ranney (1997) Sampling trace-level organics with polymeric tubings: Part I. Static studies. *Ground Water Monitoring and Remediation* 17, no. 4: 115–124.

Parker, L.V., and T.A. Ranney (1998) Sampling trace-level organics with polymeric tubings: Part 2. Dynamic studies. *Ground Water Monitoring and Remediation* 18, no. 1: 148–155.

U.S. Environmental Protection Agency Region I (1996) *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, Revision 2.* U.S. Environmental Protection Agency Region I SOP # GW 0001, US EPA Region I, Boston, Massachusetts.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

Several different small-diameter (1/2-inch and 3/4-inch) bladder pumps (from different manufacturers) were tested in 1/2-inch and 3/4-inch direct-push (DP) monitoring wells at the CRREL site in Hanover, New Hampshire. Obtaining a sample at this site has been challenging because the depth to ground water is over 100 feet and thus substantial lift is required to bring the water to the surface. Although the different brands of pumps fit into the small-diameter wells, all of them hung up in some of the wells when attempting to install them at the sampling depth. However, it was found that machining a few thousandths of an inch off the diameter of the pumps was all that was necessary to get them to the desired depth. Three brands of 3/4-inch bladder pumps were tested in the site's DP wells and delivered between 25 and 315 mL/min. Two brands of 1/2-inch bladder pumps were tested and delivered between 20 and 100 mL/min. Concentrations of TCE obtained using two different brands of a 3/4-inch diameter pump were compared and statistically significant differences were found. The same was true when the same two brands of 1/2-inch diameter pumps were compared, although the differences in this case were slight. It is believed that differences in the previous conditioning the pumps received in the wells (i.e., equilibration times for the materials with the well water) were responsible for much of these differences.

15. SUBJECT TERMS

Direct-push well pump	Sampling direct-push wells	Sampling small-diameter wells
Micro bladder pump	Sampling micro wells	Small-diameter bladder pump
Mini bladder pump		

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